

Solutions

Twentieth International Olympiad, 1978

1978/1. Since 1978^n and 1978^m agree in their last three digits, the difference

$$1978^n - 1978^m = 1978^m(1978^{n-m} - 1)$$

is divisible by $10^3 = 2^3 \cdot 5^3$; and since the second factor above is odd, 2^3 divides the first. Also

$$1978^m = 2^m \cdot 989^m,$$

so $m \geq 3$.

We can write $m + n = (n - m) + 2m$; to minimize this sum, we take $m = 3$ and seek the smallest value of $d = n - m$, such that $1978^d - 1$ is divisible by $5^3 = 125$, i.e.

$$1978^d \equiv 1 \pmod{125}.$$

We shall twice make use of the following

LEMMA. *Let d be the smallest exponent such that $a^d \equiv 1 \pmod{N}$. Then any other exponent g for which $a^g \equiv 1 \pmod{N}$ is a multiple of d .*

PROOF: If d does not divide g , then $g = qd + r$ with $0 < r < d$, and $a^g \equiv a^{qd}a^r \equiv 1 \pmod{N}$ implies $a^r \equiv 1 \pmod{N}$ with $0 < r < d$, contradicting the minimality of d . So $d|g$.

Fermat's theorem states:† For any prime p and any integer a not divisible by p ,

$$(1) \quad a^{p-1} \equiv 1 \pmod{p}.$$

For example,

$$1978^4 \equiv 1 \pmod{5}.$$

†For a proof, see e.g. p. 126 of S. L. Greitzer, *The International Mathematical Olympiads*, vol. 27 in this NML series.

Math Olympiad Questions And Solutions

Anthony Gardiner



Math Olympiad Questions And Solutions:

Problems And Solutions In Mathematical Olympiad (Secondary 2) Xiong-hui Zhao,2024-07-02 The series is edited by the head coaches of China's IMO National Team Each volume catering to different grades is contributed by the senior coaches of the IMO National Team The Chinese edition has won the award of Top 50 Most Influential Educational Brands in China The series is created in line with the mathematics cognition and intellectual development levels of the students in the corresponding grades All hot mathematics topics of the competition are included in the volumes and are organized into chapters where concepts and methods are gradually introduced to equip the students with necessary knowledge until they can finally reach the competition level In each chapter well designed problems including those collected from real competitions are provided so that the students can apply the skills and strategies they have learned to solve these problems Detailed solutions are provided selectively As a feature of the series we also include some solutions generously offered by the members of Chinese national team and national training team

Mathematical Olympiad Challenges Titu Andreescu,Razvan Gelca,2008-12-04 Hundreds of beautiful challenging and instructive problems from algebra geometry trigonometry combinatorics and number theory Historical insights and asides are presented to stimulate further inquiry Emphasis is on creative solutions to open ended problems Many examples problems and solutions with a user friendly and accessible style Enhanced motivation References

Mathematical Olympiads 1998-1999 Titu Andreescu,Zuming Feng,2000-11-02 A large range of problems drawn from mathematics olympiads from around the world

The Hard Mathematical Olympiad Problems and Their Solutions Steve Dinh,2011 This book shows the approaches to solving many difficult Mathematical Olympiad and other international problems posted at the www.mathlinks.ro the largest mathematical webpage that has most of the problems used to select the talented students of the world At the time of this book's publication the solutions to many of these problems are not yet available This book is not only as much about methods of solving mathematical problems as it is about various approaches to solving the difficult problems in general It is a first step in examining the creativity that goes into problem solving The real points of the book are the enumeration of problem solving strategies and the tricks applied to solve the problems The approaches in the book build understanding and not just methods in solving problems This book is a must read for many math students and is useful for many teachers around the world

Problems And Solutions In Mathematical Olympiad (High School 2) Shi-xiong Liu,2022-04-08 The series is edited by the head coaches of China's IMO National Team Each volume catering to different grades is contributed by the senior coaches of the IMO National Team The Chinese edition has won the award of Top 50 Most Influential Educational Brands in China The series is created in line with the mathematics cognition and intellectual development levels of the students in the corresponding grades All hot mathematics topics of the competition are included in the volumes and are organized into chapters where concepts and methods are gradually introduced to equip the students with necessary knowledge until they

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Mathematical Olympiads 2000-2001 Titu Andreescu, Zuming Feng, George Lee, 2003-10-16 Problems and solutions from Mathematical Olympiad Ideal for anyone interested in mathematical problem solving

The Mathematical Olympiad Handbook Anthony Gardiner, 1997

Mathematical Olympiad competitions started in Hungary at the end of the nineteenth century and are now held internationally They bring together able secondary school pupils who attempt to solve problems which develop their mathematical skills Olympiad problems are unpredictable and have no obvious starting point and although they require only the skills learnt in ordinary school problems they can seem much harder The Mathematical Olympiad Handbook introduces readers to these challenging problems and aims to convince them that Olympiads are not just for a select minority The book contains problems from the first 32 British Mathematical Olympiad BMO papers 1965-96 and gives hints and outline solutions to each problem from 1975 onwards An overview is given of the basic mathematical skills needed and a list of books for further reading is provided Working through the exercises provides a valuable source of extension and enrichment for all pupils and adults interested in mathematics

Problems And Solutions In Mathematical Olympiad (Secondary 1) Zun Shan, 2024-05-28 The series is edited by the head coaches of China's IMO National Team Each volume catering to different grades is contributed by the senior coaches of the IMO National Team The Chinese edition has won the award of Top 50 Most Influential Educational Brands in China The series is created in line with the mathematics cognition and intellectual development levels of the students in the corresponding grades All hot mathematics topics of the competition are included in the volumes and are organized into chapters where concepts and methods are gradually introduced to equip the students with necessary knowledge until they can finally reach the competition level In each chapter well designed problems including those collected from real competitions are provided so that the students can apply the skills and strategies they have learned to solve these problems Detailed solutions are provided selectively As a feature of the series we also include some solutions generously offered by the members of Chinese national team and national training team

USA and International Mathematical Olympiads, 2005 Zuming Feng, Cecil Rousseau, Melanie Matchett Wood, 2006 The Mathematical Olympiad books covering the USA Mathematical Olympiad USAMO and the International Mathematical Olympiad IMO have been published annually by the MAA American Mathematics Competitions since 1976 This is the sixth volume in that series published by the MAA in its Problem Book series The IMO is the work mathematics championship for high school students It takes place annually in a different country each year The aims of the IMO are 1 to discover encourage and challenge mathematically gifted young people in all countries 2 to foster friendships between mathematicians around the world 3 to create an

opportunity for the exchange of information on school syllabi and practice throughout the world The USAMO and the Team Selection Test TST are the last two stages of the selection process for the United states of America IMO team The preceding examinations are the AMC 10 or AMC12 and the American Invitational Mathematics Examination AIME Participation in the AIME USAMO and the TST is by invitation only based on performance in the preceding exams of the sequence Through the AMC contests and the IMO young gifted mathematicians are identified and recognized while they are still in secondary school Participation in the competitions provides them with the chance to measure themselves against other exceptional students from all over the world This work was prepared by Zuming Feng Melanie Matchett Wood the Leader and Deputy Leader of the 2004 USA IMO team and by Cecil Rousseau the chair of the USAMO Committee In addition to presenting their own carefully written solutions to the problems Zuming and Melanie provide remarkable solutions developed by the examination committees contestants and experts during or after the contests They also provide a detailed report of the 2000 2004 USAMO IMO results and a comprehensive guide to other material that emphasize advances problem solving This collection of excellent problems and beautiful solutions is a valuable companion for students who wish to develop their interest in mathematics outside the school curriculum and to deepen their knowledge of mathematics

USA and International Mathematical Olympiads 2004 Titu Andreescu,Zuming Feng,Po-Shen Loh,2005 The Mathematical Olympiad examinations covering the USA Mathematical Olympiad USAMO and the International Mathematical Olympiad IMO have been published annually since 1976 The IMO is the world mathematics championship for high school students It takes place every year in a different country The IMO competitions help to discover challenge and encourage mathematically gifted young people all over the world In addition to presenting their own carefully written solutions to the problems presented here the editors have provided remarkable solutions developed by the examination committees contestants and experts during and after the contests They also provide a comprehensive guide to other materials on advances problem solving This collection of excellent problems and beautiful solutions is a valuable companion for students who wish to develop their interest in mathematics outside the school curriculum and to deepen their knowledge of mathematics

A First Step To Mathematical Olympiad Problems Derek Allan Holton,2009-07-30 See also A SECOND STEP TO MATHEMATICAL OLYMPIAD PROBLEMS The International Mathematical Olympiad IMO is an annual international mathematics competition held for pre collegiate students It is also the oldest of the international science olympiads and competition for places is particularly fierce This book is an amalgamation of the first 8 of 15 booklets originally produced to guide students intending to contend for placement on their country s IMO team The material contained in this book provides an introduction to the main mathematical topics covered in the IMO which are Combinatorics Geometry and Number Theory In addition there is a special emphasis on how to approach unseen questions in Mathematics and model the writing of proofs Full answers are given to all questions Though A First Step to Mathematical Olympiad Problems is written from the perspective of a

mathematician it is written in a way that makes it easily comprehensible to adolescents This book is also a must read for coaches and instructors of mathematical competitions

Problems And Solutions In Mathematical Olympiad (Secondary 3) Jun Ge, 2022-06-16 The series is edited by the head coaches of China's IMO National Team Each volume catering to different grades is contributed by the senior coaches of the IMO National Team The Chinese edition has won the award of Top 50 Most Influential Educational Brands in China The series is created in line with the mathematics cognition and intellectual development levels of the students in the corresponding grades All hot mathematics topics of the competition are included in the volumes and are organized into chapters where concepts and methods are gradually introduced to equip the students with necessary knowledge until they can finally reach the competition level In each chapter well designed problems including those collected from real competitions are provided so that the students can apply the skills and strategies they have learned to solve these problems Detailed solutions are provided selectively As a feature of the series we also include some solutions generously offered by the members of Chinese national team and national training team

Mathematical Olympiad Problems Jagat Narain Kapur, 1995 **The Colorado Mathematical Olympiad: The Third Decade and Further Explorations** Alexander Soifer, 2017-04-27 Now in its third decade the Colorado Mathematical Olympiad CMO founded by the author has become an annual state wide competition hosting many hundreds of middle and high school contestants each year This book presents a year by year history of the CMO from 2004 2013 with all the problems from the competitions and their solutions Additionally the book includes 10 further explorations bridges from solved Olympiad problems to real mathematics bringing young readers to the forefront of various fields of mathematics This book contains more than just problems solutions and event statistics it tells a compelling story involving the lives of those who have been part of the Olympiad their reminiscences of the past and successes of the present I am almost speechless facing the ingenuity and inventiveness demonstrated in the problems proposed in the third decade of these Olympics However equally impressive is the drive and persistence of the originator and living soul of them It is hard for me to imagine the enthusiasm and commitment needed to work singlehandedly on such an endeavor over several decades Branko Grünbaum University of Washington ppi After decades of hunting for Olympiad problems and struggling to create Olympiad problems he has become an extraordinary connoisseur and creator of Olympiad problems The Olympiad problems were very good from the beginning but in the third decade the problems have become extraordinarily good Every brace of 5 problems is a work of art The harder individual problems range in quality from brilliant to work of genius The same goes for the Further Explorations part of the book Great mathematics and mathematical questions are immersed in a sauce of fascinating anecdote and reminiscence If you could have only one book to enjoy while stranded on a desert island this would be a good choice ii i p sup supp ppi Like Gauss Alexander Soifer would not hesitate to inject Eureka at the right moment Like van der Waerden he can transform a dispassionate exercise in logic into a compelling account of sudden insights and ultimate

triumph ii i pp Cecil Rousseau Chair USA Mathematical Olympiad Committee ppiA delightful feature of the book is that in the second part more related problems are discussed Some of them are still unsolved ii i pp Paul Erd s ppiThe book is a gold mine of brilliant reasoning with special emphasis on the power and beauty of coloring proofs Strongly recommended to both serious and recreational mathematicians on all levels of expertise i p Martin Gardner [The William Lowell Putnam Mathematical Competition 1985-2000: Problems, Solutions, and Commentary](#) Kiran S. Kedlaya, Bjorn Poonen, Ravi Vakil, 2020-01-16 This third volume of problems from the William Lowell Putnam Competition is unlike the previous two in that it places the problems in the context of important mathematical themes The authors highlight connections to other problems to the curriculum and to more advanced topics The best problems contain kernels of sophisticated ideas related to important current research and yet the problems are accessible to undergraduates The solutions have been compiled from the American Mathematical Monthly Mathematics Magazine and past competitors Multiple solutions enhance the understanding of the audience explaining techniques that have relevance to more than the problem at hand In addition the book contains suggestions for further reading a hint to each problem separate from the full solution and background information about the competition The book will appeal to students teachers professors and indeed anyone interested in problem solving as a gateway to a deep understanding of mathematics *Mathematical Olympiads 1999-2000* Titu Andreescu, Zuming Feng, 2002-05-16 Challenging problems in maths plus solutions to those featured in the earlier Olympiad book [Problems And Solutions In Mathematical Olympiad \(High School 1\)](#) Bin Xiong, Zhi-gang Feng, 2022-04-07 The series is edited by the head coaches of China s IMO National Team Each volume catering to different grades is contributed by the senior coaches of the IMO National Team The Chinese edition has won the award of Top 50 Most Influential Educational Brands in China The series is created in line with the mathematics cognition and intellectual development levels of the students in the corresponding grades All hot mathematics topics of the competition are included in the volumes and are organized into chapters where concepts and methods are gradually introduced to equip the students with necessary knowledge until they can finally reach the competition level In each chapter well designed problems including those collected from real competitions are provided so that the students can apply the skills and strategies they have learned to solve these problems Detailed solutions are provided selectively As a feature of the series we also include some solutions generously offered by the members of Chinese national team and national training team *Mathematical Olympiad In China (2011-2014): Problems And Solutions* Bin Xiong, Peng Yee Lee, 2018-03-22 The International Mathematical Olympiad IMO is a very important competition for high school students China has taken part in the IMO 31 times since 1985 and has won the top ranking for countries 19 times with a multitude of gold medals for individual students The six students China has sent every year were selected from 60 students among approximately 300 students who took part in the annual China Mathematical Competition during the winter months This book includes the problems and solutions of the most important

mathematical competitions from 2010 to 2014 in China such as China Mathematical Competition China Mathematical Olympiad China Girls Mathematical Olympiad These problems are almost exclusively created by the experts who are engaged in mathematical competition teaching and researching Some of the solutions are from national training team and national team members their wonderful solutions being the feature of this book This book is useful to mathematics fans middle school students engaged in mathematical competition coaches in mathematics teaching and teachers setting up math elective courses

Mathematical Olympiad Challenges Titu Andreescu, Razvan Gelca, 2013-12-01 Mathematical Olympiad Challenges is a rich collection of problems put together by two experienced and well known professors and coaches of the U S International Mathematical Olympiad Team Hundreds of beautiful challenging and instructive problems from algebra geometry trigonometry combinatorics and number theory were selected from numerous mathematical competitions and journals An important feature of the work is the comprehensive background material provided with each grouping of problems The problems are clustered by topic into self contained sections with solutions provided separately All sections start with an essay discussing basic facts and one or two representative examples A list of carefully chosen problems follows and the reader is invited to take them on Additionally historical insights and asides are presented to stimulate further inquiry The emphasis throughout is on encouraging readers to move away from routine exercises and memorized algorithms toward creative solutions to open ended problems Aimed at motivated high school and beginning college students and instructors this work can be used as a text for advanced problem solving courses for self study or as a resource for teachers and students training for mathematical competitions and for teacher professional development seminars and workshops

The American Mathematical Monthly ,1971

This book delves into Math Olympiad Questions And Solutions. Math Olympiad Questions And Solutions is a vital topic that needs to be grasped by everyone, from students and scholars to the general public. The book will furnish comprehensive and in-depth insights into Math Olympiad Questions And Solutions, encompassing both the fundamentals and more intricate discussions.

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